Early Lessons Learned from DLA Hydrogen Demonstration Projects

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Defense Logistics Agency (DLA)

- Department of Defense's largest logistics combat support agency
- Provides worldwide logistics support in war and peace time
- Supports military and civilian agencies
- Good testing ground for hydrogen-powered equipment

DLA Demonstration Projects

- Material handling equipment (MHE)
- Transportation and infrastructure
- Solid hydrogen storage
- Extended range utility vehicles

DLA's Hydrogen Fuel Cell R&D Goals

- To be an early adopter and principal demonstrator
- To foster competition in the marketplace and provide a market demand
- To support improved Technology and Manufacturing Readiness Levels by:
  - –Exercising the supply chain
  - –Testing under real world conditions
  - –Providing feedback to manufacturers
- To highlight the business case for fuel cells
- To transition the technology

Suppliers are already commenting on the positive impact the program is having on the supply chain!

Business Case Analysis

- Gathering cost and functional data about forklift operations, maintenance, and infrastructure to compare fuel cells and incumbent power sources
- Will help determine viability in DLA operations, and identify conditions under which fuel cell forklifts make sense

156,000+ operating hours
34,000+ refuelings
19,000+ kg of H2 dispensed

Hydrogen and Fuel Cell R&D Program

Objectives:

- Be an early adopter and principal demonstrator
- Provide market demand & exercise the supply chain
- Support improved Technology and Manufacturing Readiness Levels

Approach:

- 2-year forklift pilot projects at 3 DLA warehouses and JBLM (114 forklifts, 1 bus, 4 utility vehicles)
  - 4 different hydrogen production techniques
  - Team with DOE to analyze business case
- Solid hydrogen storage & extended range vehicles
- Working to transition from R&D to full operations

Customers:

- DLA Distribution Susquehanna, PA, Warner Robins, GA, San Joaquin, CA
- Joint Base Lewis-McChord (JBLM)
- Hydrogen and fuel cell industrial base

DoD Benefits:

Support DoD Energy Strategy:

- Promote energy independence
- Reduce the environmental impact
- Improve operational efficiencies

Performers: Air Products, CTC, CTE, Plug Power, Hydrogenics, East Penn, Nuvera, Gas Tech Inst, Proterra, ATK

Schedule/Milestones:

- Susquehanna, PA demonstration – Feb 09 to Sep 11
- Warner Robins, GA demonstration – Nov 09 to Nov 11
- JBLM opening – Jul 11
- San Joaquin, CA opening – Aug 11

Funding: FY07-10 $39.1M

Fuel Cell Pilot Project

DLA Distribution Susquehanna, PA

Objectives:

- Explore fuel cell infrastructure and functionality in place of lead acid batteries in forklifts
- Develop a business case for fuel cells
- Collect and analyze operational data

Approach:

- 2-year pilot project
- 55 forklifts with fuel cells (20 existing lifts and 35 new leased lifts)
- Compare products from two fuel cell producers
- Set up storage & indoor dispensing systems for delivered liquid H_2

Customers: DLA Distribution Susquehanna, PA

DOD Benefits:

- Develop knowledge of fuel cell powered fork lift capabilities, costs, limitations, and benefits
- Improve Manufacturing Readiness Levels (MRLs) and costs

Performers: Air Products, Plug Power, East Penn/Nuvera

Schedule/Milestones:

- Contract award – Aug 2007
- Operational phase – Feb 2009 to Sep 2011
- Interim business case analysis – Dec 2009
- Transition decision – Summer 2011

Fuel Cell Pilot Project

DLA Distribution Warner Robins, GA

Objectives:

- Expand infrastructure exploration to include on-site reformation and mobile refueling
- Continue to develop business case for fuel cells
- Analyze operational data

Approach:

- 2-year pilot project
- 20 new forklifts with FCs + 2 CL II lifts added (6/11)
- H_2 reformed on site from natural gas
- Test mobile refueling

Customers: DLA Distribution Warner Robins, GA

DOD Benefits:

- Further knowledge of fuel cells, on-site reformation, and mobile refueling
- Improve Manufacturing Readiness Levels (MRLs) and costs for fuel cells and infrastructure

Performers: Concurrent Technologies Corporation, Air Products, Hydrogenics, Ballard (4/11)

Schedule/Milestones:

- Contract award – Jun 2008
- Construction start – Aug 2009
- Operational phase – Nov 2009 to Nov 2011
- Transition decision – Fall 2011

Fuel Cell Pilot Project

Joint Base Lewis-McChord (JBLM), WA

Objectives:

- Explore H_2 production from wastewater digester gas
- Expand knowledge base for fuel cell applications
- Continue to develop business case
- Analyze operational data

Approach:

- 2-year pilot project
- 19 new FC forklifts
- 1 Fuel Cell Hydrid Bus
- "Green" H_2 production source
- Hub and spoke H_2 distribution

Customers: US Army (Depts. of Public Work & Logistics), Joint Base Lewis-McChord (JBLM), WA

DOD Benefits:

- Expanded knowledge of fuel cell costs and benefits for renewable H_2
- Improve Manufacturing Readiness Levels (MRLs) and costs for fuel cells and tri-generation systems
- Explore and support sustainable closed loop operations

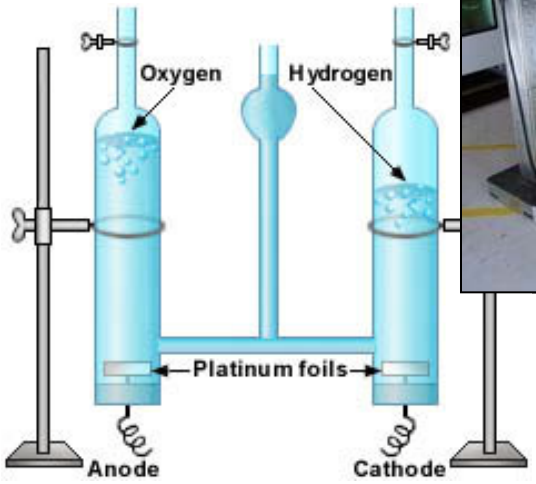
Performers: Center for Transportation and the Environment (CTE), Air Products, GTI/Versa, Plug Power, Proterra

Schedule/Milestones:

- Contract award – Jun 2009
- Construction start – Fall 2010
- Operational phase – Jul 2011 to Jul 2013

Fuel Cell Pilot Project

DLA Distribution San Joaquin, CA



Objectives:

- "Green" H_2 production from photovoltaics
- Replace propane combustion powered forklifts
- Analyze operational data
- Continue to develop business case (compare to propane operations)

Approach:

- 2-year pilot project
- Replace 20 propane forklifts with FCs
- Generate H_2 on-site using solar energy
- DLA-E negotiate a Solar Power Purchase Agreement

Customers: DLA Distribution at San Joaquin, CA

DOD Benefits:

- Expanded knowledge of fuel cell costs and benefits
- Improve Manufacturing Readiness Levels (MRLs) for fuel cells and electrolyzers
- "Green" hydrogen – reduced CO_2 emissions

Performers: CTE, APCI, Proton Energy, Plug Power

Schedule/Milestones:

- Contract award – Apr 2010
- Construction start – Apr 2011
- Solar PPA – Summer 2011
- Operational phase – Aug 2011 to Aug 2013

Fuel Cell Pilot Project

Extended Range Utility Vehicles

Objectives: Investigate and implement new designs to promote extended vehicle range for H_2 fuel cell-powered vehicles

Approach:

- Phase I: design novel H_2 storage to extend range of fuel cell utility (three awards)
- Phase II: construct and integrate the technology into vehicles supporting installation activities (Two different designs constructed; ATK & CTE)
- Utilize excess H_2 capacity
- Operate for 1 year

Customers: DLA Distribution Warner Robins, DLA Distribution Susquehanna Pennsylvania

DOD Benefits:

- Support improved H_2 storage capacity to make fuel cells more applicable to a wider range of applications
- Increased operational efficiency

Performers: Center for Transportation and the Environment (CTE), Alliant Techsystems Inc. (ATK), Lynntech, Inc.

Schedule/Milestones:

- Phase I (design) award – Apr 2009
- Detail design complete – Aug 2009
- Phase II (build) – Jan 2010
- Demonstration – 2011-2012

Lessons Learned – End User's Perspective

- Cost planning is difficult – plan a buffer for overruns
- H_2 Infrastructure sizing is important and requires detailed planning and understanding of needs (ex: digester gas seasonality):
    - Too large means high per unit costs, while too small results in excessive delivery charges and/or occasional shortages
    - Will need full year or more of data
    - May require planning for make-up fuel
- Indoor refueling raises eyebrows (safety)

Lessons Learned – End User's Perspective

- Plan for future expansion in initial design
- High level evangelists can make things happen, but…
  - Must have user buy-in (not just management)
- Plan on buying and maintaining spare fuel cells. This adds cost, but may be cheaper than downtime .
- Related topics:
  - Power Purchasing Agreement (PPA) for DoD facilities takes a long time and can be complicated
  - Solar array placement has limitations (rooftop installations have load concerns)

Business Case and Operational Data

Cost's considered:

- Fuel cell vs. Battery costs
- Fueling vs. Charging infrastructure costs
- Maintenance costs
- Utility costs
- Floor space rqmnts
- Refueling vs. recharging time
- Equipment lifespan

Operational Data Collected:

- Continuous and peak power
- Operational efficiency and degradation
- Overall lifecycle efficiency
- Mean time between failures and failure analysis
- Filling/dispensing operations
- Hydrogen production quality (purity)
- Balance of plant factors (kWh in/out)
- Other runtime details

Lessons Learned – Business Case

- Cost considerations:
  - H_2 infrastructure makes up about 30% of the overall cost
  - Major costs: H_2 delivery and storage, fuel cell O&M, infrastructure, alternative (battery) cost, power
  - Less major costs: real estate costs and labor

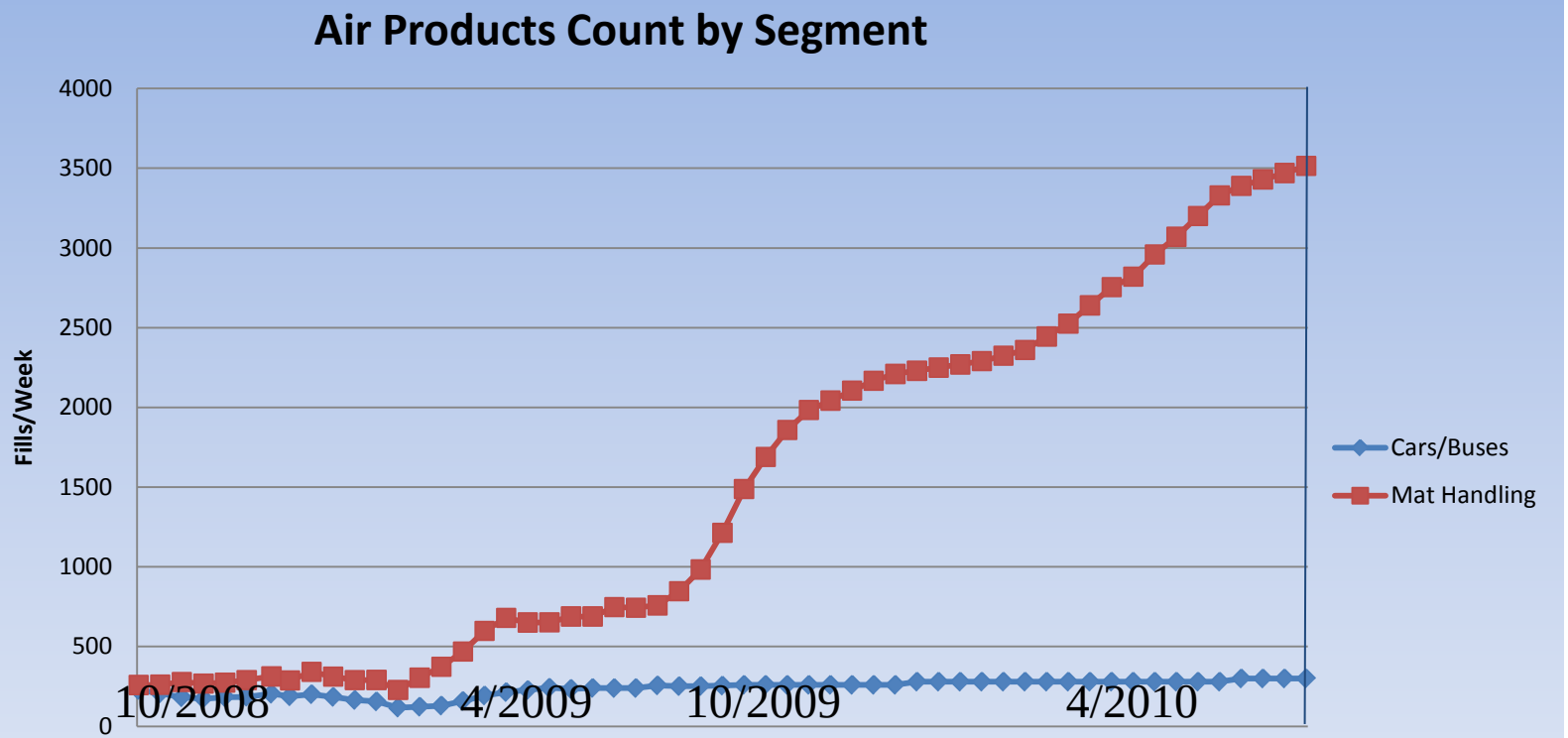
Lessons Learned – Everything matters

- Utilization matters
  - Fuel cells provide better payoff the more intensely forklifts are used (best at 2+ shifts/day, 365 days/year)
- Existing infrastructure matters
  - Fuel cells are not economic where current infrastructure enables quick battery changes
- Location matters
  - Fuel cells are more economic in places with costly labor, real estate and power. They are less so with higher natural gas costs

Lessons Learned – Everything(+) Matters

- Scale matters
  - High infrastructure and per unit O&M costs are problematic for small operations
- Delivery matters
  - Liquid H_2 is usually the cheapest source.
  - Onsite H_2 production is costly because of a lack of scale economy

Lessons Learned – Learning by Doing



Courtesy Air Products and Chemicals, Inc.

Summary

- DLA pilot projects offer opportunity to learn about various implementation options for both the manufacturers and end users
- Experience relevant outside of DLA/DoD
- Cost continues to be a factor

Questions

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Lessons Learned – TRL/MRL Improvements

- Third party FPE review, approval of system design, and installation for indoor hydrogen dispensing
- New hydrogen gas pump design and control strategy implemented for the first time
- Pump design improvements used to lower power requirements and improve efficiency and durability of the unit
- Fuel cell pack RFID identification system integration to support differentiated fill capability for certain packs

Lessons Learned – Manufacturing

- Streamlined Fuel Cell Manufacturing Processes
  - 20-person design-build workshop.
  - Work cell layout and material flow sequencing.
  - 200% throughput improvements identified.
  - Key bottlenecks identified; additional fixtures could double production capacity on current line.

Lessons Learned – Fuel Cell Design

- Fuel Cell Unit Design Innovations
  - Engineering redesign for new tank valve, reducing valve cost by 60%.
  - Design filter to increase cooling fan reliability.
  - New humidifier design to increase humidifier life.
  - Design and manufacturing improvements for air compressor, reducing cost by ~10% reduction.
  - Improved supplier coordination.
  - Stack improvement/cost reduction.